(54) IMPROVEMENTS IN OR RELATING TO SWIRL TYPE FLOW METERS

(71) We, AMERICAN STANDARD INC., a corporation organized under the laws of the State of Delaware, one of the United States of America, of 40 West 40th Street, City
5 and State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly
10 described in and by the following statement:—

The present invention relates to a volumetric flow measuring device and more
15 particularly to a swirl type flow meter.

The swirl type flow meter disclosed in British Patent Specification No. 1,022,299 comprises a conduit having a swirl generating region which causes a fluid to swirl and
20 a region where the cross-sectional area increases in the direction of the fluid flow. As the fluid flows from the swirl generating region to the increased cross-sectional area region, a hydrodynamic instability occurs
25 which results in the low pressure center of the swirling fluid to precess at a discrete frequency about the center line, i.e., it is displaced radially from the center line and rotates about the centre line. This swirl
30 precession has a frequency which may, in certain instances, be directly proportional to the flow rate of the fluid. A suitable sensor is provided in the conduit to detect this precession and to transmit the inform-
35 ation to a device which determines the flow rate from the detected precession. This is described in greater detail in said British Patent Specification No. 1,022,299.

In applying swirl type flow meters to
40 existing fluid conduits, inefficiencies occur if the inlet and outlet ends of the flow meter are not substantially of the same size and shape as the fluid conduit in which it is to be mounted.
45 Furthermore, the efficiency of the device

decreases if there are wide and numerous changes in the cross-sectional areas of the various regions and flow meters which create large disturbances in or resistances to flow therein are not desirable. Moreover, if 50 expansion ratios between regions are too great there can be excessive pressure losses while expansion ratios which are too small create oscillations which are too weak or non-existent. 55

In addition, if the ratio of average axial to average tangential velocities changes with a change in the magnitude of the axial flow rate, the meter is found to be excessively non-linear. In those flow meters which 60 cause the fluid to swirl by using swirl blades, it has been found that if the flow is deflected through very small angles, either weak oscillations or no oscillations at all occur whereas if the angle of deflection is very 65 large, large pressure losses result. Another undesirable result is that the relationship between oscillation frequency and volumetric flow rate is non-linear. Moreover, when such flow meter is used with compressible 70 fluids, undesirable compressibility effects occur.

The number of blades used is also a factor in the efficiency of such flow meters. If too many blades are used, the flow meter 75 is made unduly complex whereas if too few are used, the swirl generator is either inefficient or excessively long. According to the present invention there is provided a flow meter which comprises an internal 80 conductor having an upstream end and a downstream end, and, disposed therebetween (a) swirl means comprising between 4 and 12 deflection blades which, in use, cause fluid flowing therethrough to swirl, (b) a 85 first region downstream of said swirl means and having a given cross-sectional area, (c) a second region disposed between and communicating with said first region and said downstream end, wherein said second 90

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region has a larger cross-sectional area than said first region, the ratio of these areas being in the range 1 to 1½, to 1 to 3, whereby, in use, a low pressure centre of a swirling fluid is radially displaced from the longitudinal axis of said internal fluid conductor and rotates about said longitudinal axis, and (d) sensing means mounted downstream of said swirl means, which in use sense fluid parameter fluctuations in said swirling fluid. Preferably the ratio of the cross-sectional areas of said first region to said second region is 1 to 2.

Advantageously the swirl blades have at least a portion thereof angled, whereby, in use, fluid flowing therethrough is deflected through an angle in the range 20 to 80° to the longitudinal axis of the flow meter.

In preferred embodiment the swirl blades deflect said flow through an angle 45° to the longitudinal axis of the flow meter, and the swirl means comprises 8 swirl blades. The preferred embodiment also comprises deswirl means mounted in said internal fluid conductor, downstream of said sensing means.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawing in which:—

Fig. 1 is a perspective view of a flow meter made in accordance with the present invention;

Fig. 2 is a sectional view of the flow meter shown in Fig. 1 in which the body of the conduit is shown in cross section and the swirl generating and deswirl means are shown in elevation;

Fig. 3 is a view similar to Fig. 2 showing another embodiment of the invention; and

Fig. 4 is a view similar to Fig. 2 showing still another embodiment thereof.

Referring more particularly to the drawings and particularly to Figs. 1 and 2, the flow meter 1 comprises a hollow body portion 2 to form an internal fluid conductor or conduit 7 having an inlet 3 disposed at its upstream end and an outlet 4 disposed at its downstream end. Each end of the body portion 2 has a flange 5 and 6 extending therefrom in order to permit the flow meter 1 to be placed in line with a fluid conduit (not shown). The hollow body portion 2 comprises an upstream region 10, a center region 11 constituting a first region and downstream region 12 constituting a second region. Preferably the upstream and downstream regions 10 and 12 are of the same shape and size as the fluid conduit into which the flow meter 1 is to be placed so that no special adapters are necessary.

The center region 11 is a region having a cross-sectional area less than the cross-sectional area of the downstream region 12. In the circular flow meter shown in the drawing, the center region 11 is a region of reduced diameter.

Swirl means 13 are mounted on the upstream region 10 to cause the fluid passing therethrough to swirl. The swirl means 13 comprises a plurality of blades 14 which have an axial portion 14a and a deflecting portion 14b angled with respect to the axis. The blades 14 are mounted on an outer rim 15 attached to the walls of the upstream region 10 and are held together by an inner hub 16. Deswirl means 17, comprising a plurality of axial blades 18 mounted between hub 19 and rim 20, are fixed to the downstream region 12 to straighten out the swirling fluid, and isolate the meter from the effects of downstream disturbances.

Fluid is moved through the flow meter and as it passes the swirl blades 14, it will start swirling. As the swirling fluid passes from upstream region 10 through region 11 to the expanded region 12, an hydrodynamic instability results and precession of the low pressure center of the swirl fluid occurs. A sensor 25 is mounted downstream of the swirl blades 14, and preferably at the downstream end of the center region 11, so that the oscillations in the fluid can be detected and transmitted by a transmitter 26 to a suitable circuit.

In the preferred embodiment shown in the drawings, the upstream region 10 is connected to the center region 11 by means of a gradually tapered connecting means 27 and the center region 11 is connected to the downstream region 10 by a gradually tapered connecting zone 28. It will, of course be understood that the connections between the regions 10-11 and 11-12 may be abrupt, if desired.

In the embodiment shown in Figs. 1 and 2, the upstream region 10 and the downstream region 12 are substantially of the same cross-sectional area and the center region 11 is of a reduced cross-sectional area. The swirl means 13 are mounted in the upstream region 10 so that the fluid starts to swirl as soon as it enters the flow meter. The swirling fluid passes through the reduced center region 11 and begins to precess when the swirling fluid expands as it starts to enter the downstream region 12. Furthermore, the second region 12 has a larger cross sectional area than the first region 11.

In the embodiment shown in Fig. 3 the upstream region 10, the center region 11 which constitutes the first region and the downstream region 12 which constitutes the second region are similar to the embodiment shown in Figs. 1 and 2. However, in

this embodiment, the swirl means 13 are mounted in the said reduced diameter center region 11.

The embodiment shown in Fig. 4 may be used when the fluid conduit (not shown) with which the flow meter is to be used is to small so that it may be impractical to further reduce the diameter of the center region. Further reason for using this embodiment is that it can create less pressure losses than the embodiment shown in Figs. 1, 2 and 3. In this embodiment the upstream region 10 and the downstream region 12 are of similar cross-sectional area but the center region 11 is of an enlarged cross-sectional area. The swirl means 13 are located in the upstream region 10 and the precession occurs when the swirling fluid enters the enlarged center region 11. In this embodiment the first region extends downstream of said swirl means 13 to the junction between said upstream region 10 and the gradually tapered connecting means 27. The second region is constituted by the enlarged center region 11. Deswirl means 17 are positioned in the region 11. The sensor 25 is mounted at the downstream end of the region 10 in order to detect the oscillations in the fluid, but it could be located almost anywhere in regions downstream of swirl means 13 upstream of deswirl blades 20.

Referring to Fig. 1 and 2, it has been found that satisfactory results may be obtained when the ratio of the cross-sectional area of the center region 11 to cross-sectional area of the downstream region 12, i.e. the ratio of the cross-sectional area of the first region to the cross-sectional region, is in range 1 to 1½ and 1 to 3. The ratio of the cross-sectional areas of the upstream region 10 to the center region 11 should also be within these limits. Preferably, in the embodiments shown in the drawings, a ratio of 1 to 2 between adjacent regions 11-10 and/or regions 11-12 gives excellent results. Thus, in the embodiment shown in Figs. 1, 2 and 3, the upstream, center and downstream regions 10, 11 and 12, respectively, is 2 to 1 to 2, respectively, whereas in the embodiment shown in Fig. 4, the ratios of the upstream, center and downstream regions 10, 11 and 12, i.e. the first, second and downstream regions respectively, are 1 to 2 to 1, respectively.

With the ratios outlined above, it has been found that oscillations are produced which are strong enough to be reliably detected without resulting in excessive pressure losses, and in conjunction with swirl generators as described, linearity can be achieved.

The swirl means 13 shown in the drawings comprises a plurality of swirl blades 14 in which the deflecting portions 14b are so shaped and angled as to deflect the flow of the fluid and to cause the fluid to swirl. In order to give satisfactory results, the deflecting portion 14b of blades 14 are so shaped as to deflect the flow of fluid through an angle of between about 20° and about 80° to the longitudinal axis of the flow meter. Preferably, and as shown in the drawings, they are shaped so as to deflect the flow of the fluid through an angle of about 45°. This will cause the fluid to swirl with sufficient strength to give strong oscillations without creating great pressure losses. In addition, the arrangement of the blades generates a preferred swirl in which the ratio of axial to tangential velocities remains substantially the same regardless of the magnitude of the axial flow rate. Furthermore, by using the swirl angles outlined above, in conjunction with the described area ratios, the relationship between oscillation frequency and volumetric flow rate can be made linear, within small limits, over wide flow rate ranges.

It has also been found that the number of blades 14 which are to make up the swirl means affects the operation of the flow meter. Between 4 and 12 blades may be used for the purposes of the present invention to result in a flow meter which is efficient without being unnecessarily complex. It has been found that 8 blades, as shown in the preferred embodiment in the drawings, give satisfactory results.

It will thus be seen that the present invention provides an improved flow meter which can be used with existing fluid conduits without the need of special adapters and which does not have wide and numerous changes in cross-sectional area. The present invention also provides a flow meter in which the ratio of axial to tangential velocities does not change appreciably with a change in the magnitude of the axial fluid flow and which will generate a swirl which is not too large to create an excessive pressure loss to the fluid flow and not too small to result in weak oscillations, and in which the relationship between oscillation frequency and volumetric flow rate can be made linear within small limits over wide flow rate ranges. The invention further provides a flow meter which has an efficient swirl generator without unduly increasing the complexity of the flow meter.

WHAT WE CLAIM IS:—

1. A flow meter which comprises an internal fluid conductor having an upstream end and a downstream end, and, disposed therebetween, (a) swirl means comprising between 4 and 12 deflection blades which, in use, cause fluid flowing therethrough to swirl, (b) a first region downstream of said swirl means and having a given cross-sectional area, (c) a second region disposed

between and communicating with said first region and said downstream end, wherein said second region has a larger cross-sectional area than said first region, the ratio of these areas being in the range 1 to 1½, to 1 to 3, whereby, in use, a low pressure centre of a swirling fluid is radially displaced from the longitudinal axis of said internal fluid conductor and rotates about said longitudinal axis, and (d) sensing means mounted downstream of said swirl means, which in use sense fluid parameter fluctuations in said swirling fluid.

2. A flow meter as claimed in Claim 1, wherein the ratio of the cross-sectional areas of said first region to said second region is 1 to 2.

3. A flow meter as claimed in Claim 1, or 2, wherein said swirl blades have at least a portion thereof angled whereby, in use, fluid flowing therethrough is deflected through an angle in the range 20 to 80°. to the longitudinal axis of the flow meter.

4. A flow meter as claimed in Claim 3, wherein, in use, said swirl blades deflect said flow through an angle 45° to the longitudinal axis of the flow meter.

5. A flow meter as claimed in Claim 1, 2, 3, or 4, wherein said swirl means comprise 8 swirl blades.

6. A flow meter as claimed in any one of the preceding claims, which further comprises deswirl means mounted in said internal fluid conductor, downstream of said sensing means.

7. A flow meter, substantially as hereinbefore described, with reference to the the accompanying drawing.

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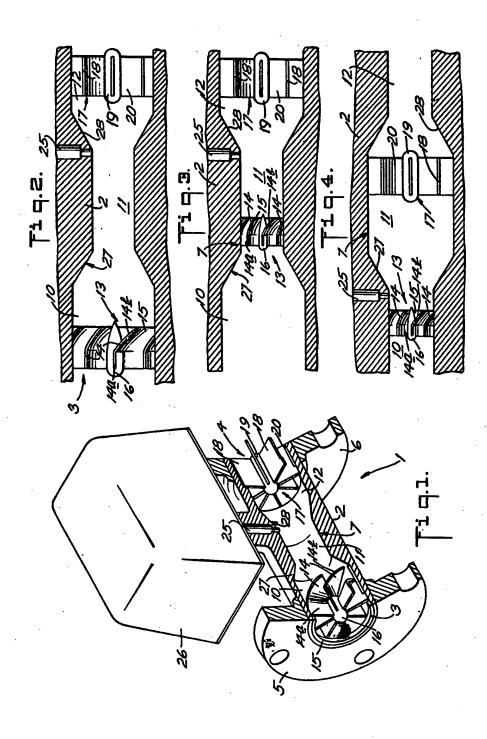28 Southampton Buildings,
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